CLAIMS

What is claimed is:

1. An apparatus comprising:

a porous anode substrate in fluid communication with a source of hydrogen gas;

a porous cathode substrate in fluid communication with a source of nitrogen gas; and

an electrolyte disposed within a matrix, wherein the matrix is disposed between the porous anode substrate and the porous cathode substrate.

2. The apparatus of claim 1, further comprising:

a catalyst disposed on the anode substrate facing the electrolyte matrix.

3. The apparatus of claim 1, further comprising:

a catalyst disposed on the cathode substrate facing the electrolyte matrix.

4. The apparatus of claim 1, wherein the porous anode substrate has a porosity greater than 40 percent.

5. The apparatus of claim 1, wherein the porous anode substrate has a porosity greater than 90 percent.

6. The apparatus of claim 1, further comprising:

a metal membrane having a thickness of between 1 and 200 microns disposed on the porous anode substrate facing the electrolyte matrix.

7. The apparatus of claim 6, wherein the metal membrane is made from a metal selected from palladium, a palladium alloy, iron, tantalum, lanthanide metals, and combinations thereof.

8. The apparatus of claim 6, further comprising a matrix supporting the metal membrane, wherein the matrix is formed from a material selected from nickel and nickel-containing alloys.

9. The apparatus of claim 6, further comprising a matrix supporting the metal membrane, wherein the matrix is formed from a material selected from transition metals and transition metal-containing alloys.

10. The apparatus of claim 6, further comprising a matrix supporting the metal membrane, wherein the matrix is formed from an electrically conducting inorganic ceramic material.

11. The apparatus of claim 1, further comprising:

a metal membrane having a thickness of between 1 and 200 microns disposed on both sides of the porous anode substrate, wherein the porous anode substrate is a non-noble metal and the metal membrane is palladium or a palladium-containing alloy.

12. The apparatus of claim 11, wherein the non-noble metal is selected from iron, tantalum, and lanthanide metals.

13. The apparatus of claim 6, wherein a catalyst is disposed on a surface of the metal membrane facing the electrolyte.

14. The apparatus of claim 13, wherein the catalyst comprises a metal selected from iron, ruthenium and combinations thereof.

15. The apparatus of claim 1, wherein the porous cathode substrate is made from nickel, a nickel-containing compound, or a nickel alloy.

16. The apparatus of claim 1, wherein the porous cathode substrate is made from metal, metal alloy, ceramic or a combination thereof.

17. The apparatus of claim 1, wherein the porous cathode substrate has a pore size of about 0.2 microns.

18. The apparatus of claim 1, wherein the electrolyte supports migration of negatively charged nitrogen-containing species between the cathode substrate and the anode.

19. The apparatus of claim 1, wherein the electrolyte comprises a molten salt.

20. The apparatus of claim 19, wherein the molten salt comprises one or more metal chlorides.

21. The apparatus of claim 19, wherein the molten salt comprises one or more metal salts selected from chlorides, iodides, bromides, sulfides, phosphates, carbonates, and mixtures thereof.

22. The apparatus of claim 19, wherein the molten salt comprises lithium chloride and potassium chloride.

23. The apparatus of claim 22, wherein the molten salt further comprises a metal nitride salt.

24. The apparatus of claim 22, wherein the molten salt electrolyte has a greater molar concentration of lithium chloride than potassium chloride.

25. The apparatus of claim 22, wherein the molten salt electrolyte further comprises rubidium chloride, cesium chloride, ruthenium chloride, iron chloride, or a mixture thereof.

26. An apparatus comprising:

a plurality of electrolytic cells and a bipolar plate separating each of the plurality of electrolytic cells, wherein each of the plurality of electrolytic cells comprises:

a porous anode substrate in fluid communication with a source of hydrogen gas;

a porous cathode substrate in fluid communication with a source of nitrogen gas;

an electrolyte disposed within a matrix placed between the porous anode substrate and the porous cathode substrate;

an anodic fluid flowfield in fluid communication with the porous anode substrate opposite the matrix; and

a cathodic fluid flowfield in fluid communication with the porous cathode substrate opposite the matrix.

27. The apparatus of claim 26, wherein the anodic fluid flowfield has a first face that is in electronic communication with the porous anode substrate and a second face in electronic communication with a first bipolar plate, and wherein the cathodic fluid flowfield has a first face that is in electronic communication with the porous cathode substrate and a second face in electronic communication with a second bipolar plate

28. The apparatus of claim 26, further comprising:

a hydrogen gas manifold for providing fluid communication between the source of hydrogen gas and each of the anodic fluid flowfields; and

a nitrogen gas manifold for providing fluid communication between the source of nitrogen gas and each of the cathodic fluid flowfields.

29. The apparatus of claim 28, wherein the hydrogen gas manifold and the nitrogen gas manifold are each selected from an internal manifold and an external manifold.

30. The apparatus of claim 26, wherein the porous anode substrate and the porous cathode substrate are each selected from metal foams, metal grids, sintered metal particles, sintered metal fibers, and combinations thereof.

31. The apparatus of claim 26, wherein the anodic fluid flowfield is metallurgically bonded to the bipolar plate.

32. The apparatus of claim 31, wherein the metallurgical bonds are formed by a process selected from welding, brazing, soldering, sintering, fusion bonding, vacuum bonding, and combinations thereof.

33. The apparatus of claim 26, wherein the cathodic fluid flowfield is metallurgically bonded to the bipolar plate.

34. The apparatus of claim 26, wherein the anodic fluid flowfield is metallurgically bonded to the porous anode substrate.

35. The apparatus of claim 26, wherein the cathodic fluid flowfield is metallurgically bonded to the porous cathode substrate.

36. The apparatus of claim 26, wherein the porous cathode substrate is selected from metal carbides, metal borides and metal nitrides.